Development of an Optimal Brain Computer Interface based on Motor Imagery

Authors: Vaishnavi B Mohan[(1),(2),(3),(4)] Zahra Emami[(1),(2),(3)] and Dr.Tom Chau[(1),(2),(3)]

(1) PRISM Lab, Bloorview Research Institute (2) Holland Bloorview Kids Rehabilitation Hospital (3) University of Toronto (4) National Institute of Technology Karnataka, India

Background

A Brain-Computer Interface (BCI) is a technology that uses neural signals to control various devices and applications.

Motor Imagery (MI), the imagination of movement of the limbs is one such task which can be used as a reliable control signal for a BCI . This signal can be captured over the sensorimotor cortex region of the brain using Electroencephalography (EEG). This signal is processed in a BCI and can be used to control various applications to enable people with motor disabilities to interact with their environment.

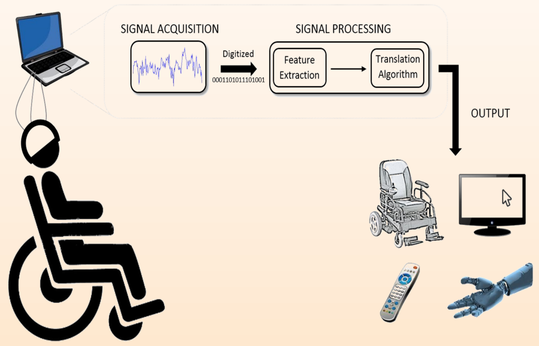

Fig 1. Illustration of a BCI with a participant performing MI

Methods and analyses

Data was obtained from 11 participants asked to perform MI of right and left hand movements

Neural signals were captured using EEG with 15 electrodes over the sensorimotor cortex region

Hand motion data was captured using Mechanomyography (MMG) with 4 sensors, two over each palm

Signal Processing and classification.
Features considered:

- Channel information using **Common Spatial Patterns** (CSP)
- Feature selection done using **Fast Correlation-Based Filter** (FCBF)
- Linear Discriminant Analysis for classification
- Performance parameters: Mean classification accuracy and Area Under the Receiver-operating-curve (AUC)
- Performance was optimized with respect to the features obtained using CSP and FCBF

Signal energies corresponding to MMG data of real movement and MI were computed.

Large hand movements were identified using a reference energy value.

Trials with small hand motion artifacts were identified using Short Time Fourier Transform analysis

Research Objective

Development of a viable BCI based on MI, optimized for good performance that can ultimately be used as an access technology by people with motor disabilities.

1) In order to reduce the effect of real hand motion artifacts on the features corresponding to MI and consequently on the BCI performance, a development of a technique for hand motion artifact removal was made.
2) To achieve the best performance for the BCI, an exploration of the most optimal features for classification of the acquired MI signal were examined.

Results

Hand motion artifact removal

Participant	Session number	Percentage of trials flagged
1	1	0
	2	0
2	1	0.7
	2	1.4
3	1	5.6
	2	8.3
4	1	0
	2	1.3
5	1	0
	2	0
6	1	0
	2	4.1
7	1	11.8
	2	0
8	1	6.9
	2	0
9	1	0
	2	0
10	1	0
	2	2.1
11	1	0
	2	2.1

Table 1. Percentage of trials identified with motion artifacts

Significant Features used for classification

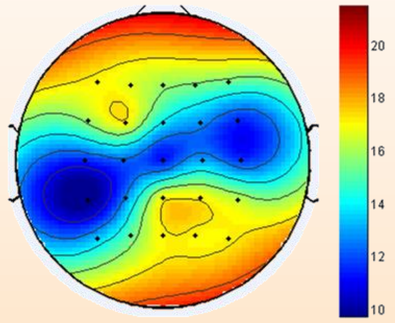

Fig 2. Beta frequency band power over the sensorimotor cortex region relative to a baseline period

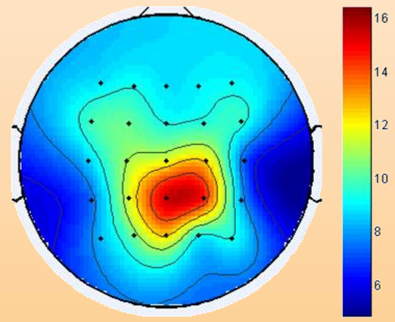

Fig 3. Alpha frequency band power over the sensorimotor cortex region relative to a baseline period

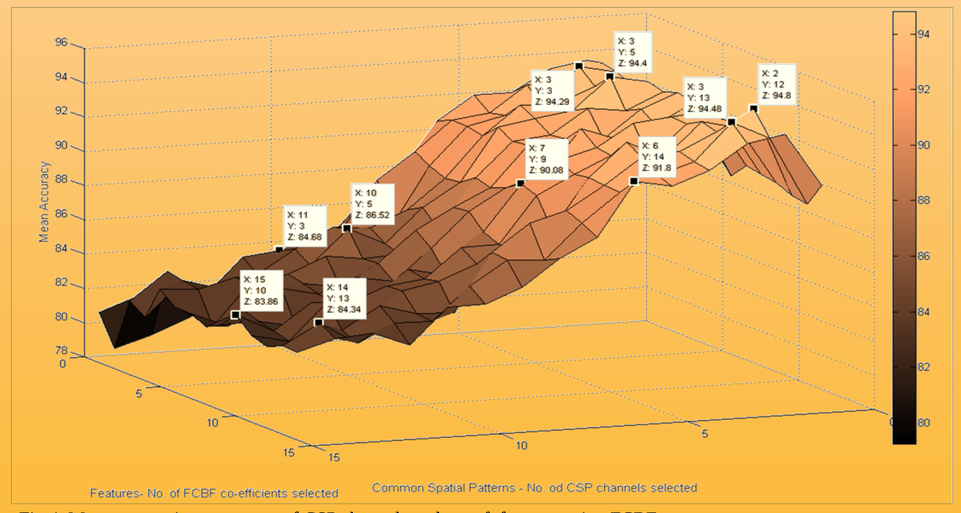

Fig 4. Mean accuracies versus no. of CSP channels and no. of features using FCBF

Optimal values across all participants:
No. of channels selected using **CSP = 3**; No. of features selected using **FCBF = 7**

Conclusion

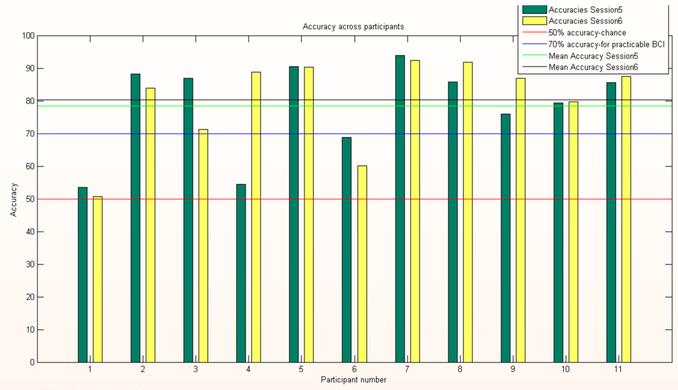

Fig 5. Classification accuracies across participants

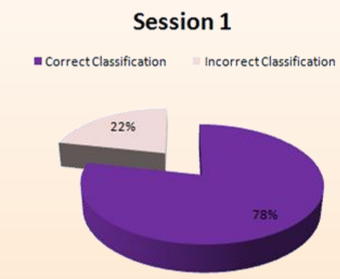

Fig 6. Mean accuracies of Session 1

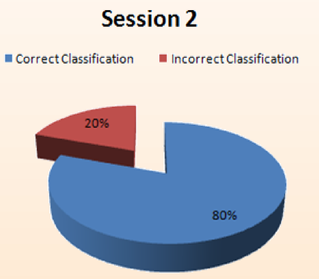

Fig 7. Mean accuracies of Session 2

The trials with hand motion artifacts were removed from the EEG data which was then used for the development of this BCI. This also substantiates the idea of developing a practicable BCI solely with neural signals.

Relevance to Holland Bloorview Clients

The BCI eliminates the requirement of a conventionally functioning motor control system to enable people with disabilities to control various applications simply with their neural signals. The participants in the study were naïve users, substantiating the possibility of accessibility of BCI systems by a larger population of interest.

References

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